DOCUMENT RESUME

ED 129 279 IR 004 062

AUTHOR	Broderick, W. R.; And Others
TITLE	Off-Line Computer Aided Learning Project; The Development of Educational Material. The Second Report.
INSTITUTION	London Borough of Havering (England).
SPONS AGENCY	Social Science Research Council, London (England).
PUB DATE	May 73
NOTE	73p.; For related documents see IR 004 063-064; Not available in hard copy due to marginal reproducibility of original document
EDRS PRICE	MF-$0.83 Plus Postage. HC Not Available from EDRS.
DESCRIPTORS	*Academic Achievement; Biology Instruction; *Computer Assisted Instruction; Computer Programs; Instructional Materials; *Material Development; Secondary Education; *Test Construction
IDENTIFIERS	Computer Aided Learning; England (London Borough of Havering); Off Line Systems

ABSTRACT

During the period from May, 1971 until June, 1973, the Off-Line Computer Aided Learning Project of Havering Borough, London, England, continued to generate, implement, and evaluate computer-based instruction programs. Trials were conducted to test the effectiveness of modifications to computer programs and to assess the educational, psychological, and sociological impacts of the system. This report describes the development of the materials, summarizes the procedures for testing and evaluating, discusses the results, and provides samples of tests and survey instruments. (EMH)

****
* Documents acquired by ERIC include many informal unpublished *
* materials not available from other sources. ERIC makes every effort *
* to obtain the best copy available. Nevertheless, items of marginal *
* reproducibility are often encountered and this affects the quality *
* of the microfiche and hardcopy reproductions ERIC makes available *
* via the ERIC Document Reproduction Service (EDRS). EDRS is not *
* responsible for the quality of the original document. Reproductions *
* supplied by EDRS are the best that can be made from the original. *
****

ED129279

BEST COPY AVAILABLE

OFF-LINE COMPUTER AIDED LEARNING PROJECT

THE DEVELOPMENT OF EDUCATIONAL MATERIAL

THE SECOND REPORT

U S DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

IR001402

CONTENTS

	Section
Acknowledgements	
Introduction	
The Computer Programs	1.00
Educational Material Produced	2.00
Production of Teaching Material	3.00 - 3.04
Test Construction	4.00 - 4.03
Evaluation of the System	5.00 - 5.05
Trial 1: Autumn 1972	6.00 - 6.09
Trial 2: Spring 1973	7.00 - 7.19
Discussion of the results of Trials 1 and 2	8.00 - 8.04
Statistical Programs	9.00 - 9.03
Operation of CAL System	10.00 - 10.02

ACKNOWLEDGEMENTS

The Off-Line Computer Aided Learning Project was established in January 1970 and is supported by the Council of the London Borough of Havering and research grants from the Social Science Research Council, the Ford (Dagenham) Trust and an industrial company.

The project staff would like to thank the heads of all the secondary schools in Havering for their co-operation. We would also like to record our special thanks to those teachers who have actually used the CAL system in their classrooms in the two trials during the academic year 1972/73. In particular our thanks go to:-

Mrs. E. Waddoups and Mr. P. Whitton - (Abbs Cross Technical School)

Mrs. E. Whipps - (Bush Elms Secondary School)

Mrs. Harry and Mr. Williams - (Dury Falls Secondary School)

Miss V. Bussey - (Hall Mead Secondary School)

Mrs. Loganathan, Mr. Knight and Mr. W. Barnes - (Hylands Secondary School)

Mrs. Jones and Mr. Mecoy - (Maylands Secondary School)

Mr. D. Hardy - (Royal Liberty School)

Mrs. Austin, Mrs. Gervassio and Mrs. Kutz - (Sacred Heart of Mary R.C. Secondary School)

Mr. M. Armstrong - (Rainham Secondary School)

W.R. BRODERICK

K.F. LOVATT

G.B. KEARIN

MAY 1973.

INTRODUCTION

The Off-Line Computer Aided Learning Project, which is funded jointly by the Social Science Research Council and the Council of the London Borough of Havering, was established in January 1970. The project team presented its first report on the Development of Educational Material in May 1971 [Broderick, Lovatt and Bryant, 1971].

This report is the second report, covering the period from May 1971 until June 1973. In this period, the Computer Aided Learning system, as specified in the original project proposal has been implemented on the Hewlett Packard 2116C computer system and has been used in the trials described in this report. The teaching material also used in the trials has been written and validated; thus the project team have now built up not only a system for computer managed instruction, but also experience and expertise in the development of educational material to be used within that system. The purpose of subsequent trials beyond those described in this report will be two fold.

Firstly, to enable us to test the effectiveness of the modifications we have made to the computer system and secondly, to discover more about the behaviour of the system from the point of view of education, psychology and sociology.

THE COMPUTER PROGRAMS

In order that the educational work can be seen in context, it is necessary to present some information about the suite of computer programs which form the core of the Computer Aided Learning system.

These programs have been written in Hewlett Packard Algol to be run under the DOS-M Operating system on a 24K Hewlett Packard 2116C Computer System. They are written in Algol to ease communication and transferability and have been written as a series of modules which operate on a common data base.

The transfer of these programs to another computer system is a relatively straight forward task for an experienced programmer, so long as the computer system involved has a batch operating system which allows the use of the disc files and also a very large core capacity or segmentation and chaining within the operating system.

In view of the amount of output produced a line printer is a most valuable peripheral.

These programs, which have been written as a series of modules, have been described in the Systems Manual of the CAL system and are also documented at a program level.

In designing the computer programs, it has been necessary initially to make a number of decisions based upon common sense rather than scientific reasoning, simply because the basic science needed to make these decisions does not exist. It is expected that future research will enable us to review the decisions made and study ways of improving the performance of the system as a whole.

EDUCATIONAL MATERIAL PRODUCED

As explained in Broderick, Lovatt and Bryant 1971, the educational material within this system is designed to enable us to teach respiration and photosynthesis in roughly the way it is described in the Nuffield Biology III, texts. The respiration course is now completed, although of course capable of some improvements and has been the basis of the trials so far.

Due to a serious illness of a key member of the team, the photosynthesis material has been developed using groups of teachers as authors. In the first case the group worked as a committee under a chairman, which provided some operational difficulties. The second experiment, which is in the course of being conducted, where two individuals working in the same school undertake writing of material; thus hoping to improve continuity and communication. It may appear at first sight that this activity will be of peripheral interest to the project, but computer managed instruction is only going to be widely used when

1) it helps solve real educational problems;
2) a lot of material is available for use with a particular system; and
3) when teachers are able to participate in the creation of the material which they are going to use.

The final difficulty encountered has been in terms of evaluation. It appears that there is no generally accepted set of criteria or means whereby a system which dynamatically re-allocates the terminal objectives of each individual student can be evaluated. In practical terms, the research team are under an obligation to provide evaluation information which will satisfy the expressed needs of all the interested parties; students, teachers, parents, local authorities and other research workers.

In the same way as the Computer Aided Learning system has become more complex than was originally envisaged, so has the evaluation.

PRODUCTION OF TEACHING MATERIAL

The procedure we adopted for the production of the teaching CALTS is described in our previous publication (Interim Report 1971). Since this publication we have developed a set of CALTS covering the topic of Respiration for those students who are below average ability, and started the production of CALTS on Photosynthesis, which is the topic for the second part of the course.

Teaching material for the below average

On the topic of respiration we have, in a more or less complete form, a series of CALTS to cater for high ability students and a series for those students with average ability. These are relatively successful teaching modules in that, providing there is some effort from the student, then he is able to complete the work they contain and achieve a pass score on the post CALT tests.

In addition we have developed a series of CALTS for the student with below average ability but have met with certain difficulties which, unless they are solved satisfactorily, will prevent the student from benefitting as much as he might from the system.

The chief problem arises from the reading difficulties suffered by many of these below-average students. It is quite possible to overcome most of the communication problems encountered by poor readers with the teaching sections on the CALTS by cutting down severely on unimportant details and by extensive use of diagrams and cartoon sequences.

These methods have enabled us to devise CALTS containing about 50% of the terminal objectives which compose the course for the average students in a form acceptable for the below average students.

Watching these students using the materials in class gives the distinct impression that they know what they are doing, an impression hardened by verbal questioning whilst they are working. However, their performance on the post CALT tests is not as high as might be expected. We are unable to state definitely why this is and there are a number of suggested reasons including lack of real understanding of the work by the students, and invalidity of the test questions. However, teachers using the system feel that the problem stems from the students' reading difficulties because although the teaching material may be in picture form the test questions have to be read. It may be possible to solve this problem by recording the test questions on magnetic tape and providing the student with a simple cassette recorder so that he can play and replay the questions whilst trying to read them from the test sheet.

TEACHER CALT WRITING GROUPS

GROUP 1.

It has been an intention of the design team to investigate the possibility of teachers writing the teaching CALTS to use on the system. This became a reality at the beginning of 1972 when a group of teachers was formed under the Chairmanship of Mr.D.M.Hardy for the purpose of writing CALTS for Level 1 students on part of the Photosynthesis Course. It was desirable to attempt this at the time because the project text writer was ill in hospital and it looked as though his recovery would be very slow. Including the Chairman seven teachers were involved. All were volunteers who would be paid for their services.

The procedure adopted was as follows:

1. The basic Level 1 course structure was mapped out by the project staff using the list of objectives composed by a working party of Havering teachers at the beginning of the projects.

2. The objectives for each part of the course were listed and classified as either practical work or theory.

3. Each part of the course was allocated a span of time (20 minutes for a single lesson, 40 minutes for a double lesson).

4. A list of objectives for each part of the course was then handed over to the Chairman of the teachers CALT writing group. At the first meeting of the group the Chairman distributed one part of the course to each of the volunteers, according to their particular preference. An example of all these lists is shown in figure 1.

5. The group were advised to go away and familiarize themselves with the list of objectives, and the relevant sections in the Nuffield Biology Text III and the corresponding Teachers Guide.

6. Each writer now analysed the objectives by making a detailed list of:

   A. Facts and techniques to be taught.

   B. What facts and techniques are assumed to be known by the student.

7. The analyses were then submitted to the group's Chairman for collation. Repetitions for example were eliminated. The analyses were returned with criticisms and comments.

8. Each teacher was then asked to write a few test questions and submit them to the Chairman. This enabled a further check whether the teacher was keeping to his objectives.

9. The text was then written with a reference to examples in the interim report of the CAL project (Broderick, Lovatt and Bryant 1971) and other available material.

10. The rough first draft was tried on a non-biological friend or colleague to throw out the more obvious errors. It was then tested on one or two bright pupils who were not afraid to say what they thought of it.

11. The Calts were duplicated and their post tests added. These post tests have been drawn up independently by the CAL project staff. The CALTS were then ready for validation testing.

12. Most of the validation testing was carried out by the chairman of the group, but the CALTS were returned to the relevant teacher after the students had completed them for frame and post test analyses.

13. The analyses allowed a further revision of the CALTS to be carried out.

Problems encountered.

1. The most difficult part of the operation seems to be the analysis of the objectives and was the least successful.

2. Some of the texts failed to maintain students interest.

3. Co-ordination of the texts was difficult and led to a certain discontinuity.

4. Validation of the texts was very difficult due partly to the lack of suitable students, but also because teachers did not all complete their CALTS on the specified date. The complete process took eleven months.

Results.

1. Between them the group produced the teaching material for six CALTS which would keep the average Level 1 student occupied for about 220 minutes. That is about three double period practical lessons and three homeworks.

2. Six teachers in Havering now have a basic understanding of the principles of writing teaching material for the CAL project.

3. We now know of some of the difficulties likely to arise when using this method of CALT production.

GROUP 2.

Considering the difficulties involved we think the exercise described above was successful. However, the problems of co-ordination and validation seemed partly responsible for the long time it took to produce the six CALTS. Consequently, we recently started another teacher CALT writing group having a different organization than the first group, in the hope that it will solve the difficulties indicated.

The basic idea is that two biology teachers in one school are given the responsibility of writing the CALTS for an agreed part of the course.

They are paid to write the CALT teaching material but not the tests which are composed by the project staff. In addition the teachers are responsible for validating the CALTS they write in their own school.

This exercise is in progress at the moment.

FIGURE 1 Specimen of objectives list as used by teachers in CALT writing group

Subject Identification of Starch in Green Leaf

Objectives

1. The student will be able to use iodine solution to identify the absence or presence of starch in a green leaf.

2. The student will be able to recall the stages gone through when using iodine solution to identify starch in a green leaf.

3. The student will be able to use his knowledge of the results of the iodine test to interpret the results of this test in a variety of similar situations.

This is scheduled as a practical lesson for approximately 40 minutes.

Objective 3 indicates that the principles of the test should be emphasized so that the student is able to apply his knowledge in situations other than the one in which it was learned.

TEST CONSTRUCTION

Basically this CAL system is a testing system. It is composed of a network of short tests, the network itself starting and ending with the same long test. To a large extent the success or failure of the system is judged upon the student success in these tests and therefore a lot of time has been spent on their construction.

Problems

As it was suggested in the earlier report(Interim Report 1971) two main problems face the test constructor and these are

1. Assuring that the individual test questions match the educational objective they are testing. This is a matter for expert judgement.
2. Including in the test sufficient test questions to give a reliable result.

When constructing a large test which is supposed to test a wide range of student abilities we can add a third difficulty:

3. Assuring that the sample of questions selected for the test accurately reflects the composition of the course it is testing.

Roebuck (1972) lists the following three approaches to the production of criterion reference tests

A. By random sampling of items from the pool of items all of which are representative of the problems that can be passed by persons having the desired specific capability.

B. By using items which have a direct operational link with the construction which preceded the test.

C. By defining the particular performance domain in terms of a hierarchy of sub-skills done by using testing procedures to sequentially or otherwise test these components on the desired performance.

A combination of the approaches labelled B and C were used in the construction of post lesson tests. This together with parallel questions which were not actually used in the post lesson tests gave us a pool of questions from which the post course test could be composed. Roebuck (1971) suggests that sampling from this pool should be at random. We have not selected our test questions for the course post test at random, but we selected them to reflect the biases of the course.

The basic structure of the CAL respiration course is represented diagramatically in figure 2.

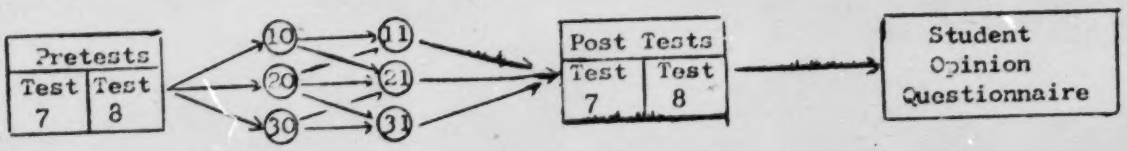

Figure 2.

The main feature of the tests are as follows:

1. The pre test and post tests are identical

2. The pre test and post tests are divided into two parts, one labelled Test 7 and the other labelled Test 8.

3. Pre test 7 tests are mainly for the pre-requisite items which the computer will use to route the students to different CALTS during the course. Part of this information is basic biology, part basic science and part basic mathematics. High ability students achieve a high pre test score (over 70%) on this test and therefore the raw gain shown by the post test is small. Low ability students (pretest 7 score below 35%) are able to show a much greater raw gain score on the post test 7.

4. . Test 8 is designed to demonstrate that students learn something during the CALT course. Misinterpretation of the results of test 8 is likely unless its constructional structure is understood. The CAL course is supposed to be suitable for mixed ability classes and includes work for high ability and low ability students. High ability students are able to complete more work and work which is of a greater complexity than the low ability students. During the planning of the course, a list of objectives suitable for the high ability students was drawn up. The objectives for the low ability students were selected as a sub set from this list of high ability objectives. The composition of test 8 reflects this and is as follows:

Test 8

Questions answerable by level 1 students = 100%

Questions answerable by level 2 students = 86%

Questions answerable by level 3 students = 50%

After the first experimental run of the system during the Autumn term of 1972 some changes were made to test 8. These changes were as follows:

1. Two questions were removed because of very high pretest facility indices.
2. The two questions removed were replaced by one question on the Level 1 material and one global question.
3. Four questions were added for better coverage of the Level 1 material.

The resulting test was given the number 9 and has the following composition

Test 9.

Questions answerable at level 1 = 100%

Questions answerable at level 2 = 67%

Questions answerable at level 3 = 41%

Test 9 was used instead of test 8 for the second run of the experiment during the Spring term of 1973.

5. Each question in the tests is classified by its taxonomy level. We have simplified Broom's (1966) taxonomy to produce the taxonomy reported in our previous publication (1971). It contains five taxonomy classes viz 1. Recall, 2. Manipulation, 3. Application, 4. Analysis, 5. Interpretation. Recorded below are analyses of the tests 7, 8 and 9 using the simplified taxonomy.

Test 7. Taxonomy Level Distribution.

Taxonomy Level	1	2	3	4	5
Number of questions (total = 39)	7	3	28	1	
Number of questions as a percentage	17.9	7.6	71.8	2.5	

Test 8. Taxonomy Level Distribution.

Taxonomy Level	1	2	3	4	5
Number of Questions (Total = 30)	15	7	6	2	
Number of questions as a percentage	50.0	23.3	20.0	6.6	

Test 9. Taxonomy Level Distribution.

Taxonomy Level	1	2	3	4	5
Number of questions (Total = 34)	15	7	9	3	
Number of questions as a percentage	44.1	20.5	26.4	8.8	

objectives 2 and 3. The results in this report are from Trials 1 and 2.

Methods

Other projects similar in purpose to this have adopted a variety of methods to determine whether or not project objectives have been achieved. We are using the following data sources:

1. Student performance on course subject matter tests, including pre course and post course tests in addition to the post lesson tests.
2. Students' opinions as determined by a post course questionnaire.
3. Teachers' opinions as determined by a post course interview.

The remainder of this section is devoted to a description of the methods used during Trials 1 and 2 of the CAL system.

Objectives

This CAL system uses the computer to make it possible for a class of students to pursue individual pathways through a course of learning material. The objectives of the trials of the project are as follows:

1. To demonstrate that the design objectives of the system have been achieved.
2. To demonstrate that the computer is making a useful contribution to student progress within the system.
3. To demonstrate that individual work with computer guidance is itself advantageous compared with learning systems without a computer.

The first objective is relatively easy to evaluate and is a matter of observation. The team set out to design a system which would do the following:

(i) Automatically route students individually through a course of learning material without teacher intervention.

(ii) Mark the tests the student completes after each learning task.

(iii) Output for each student the marks achieved from the previous lesson's work.

(iv) Output for the teacher information on student progress.

((v) Output for the teacher administrative information which would make individual work possible.

(vi) Allow the teacher to manually override the automatic routing system and allocate CALTS chosen by the teacher.

(vii) Allow the student to work at his own rate.

The other two objectives are concerned with the problem of showing that the system is an aid to instruction, either that it enables the student to do useful things which other systems do not allow, or that it does what other systems do but more effectively.

Three trials have been planned in which the system will be evaluated. Trial 1 has been completed and was concerned mainly with objective 1. Trial 2 has been completed and was concerned mainly with objective 2. Trial 3 will be conducted during Autumn 1973 and will be concerned with

The Sample Population

All secondary schools in the London Borough of Havering were circulated with details of plans for the 1972/73 set of system trials. Schools were invited to take part and state their preferences for autumn or spring trials. From these volunteer schools two populations were selected, one for the Autumn trial and the other for the Spring trial. The composition of each of the samples is described in the section describing the appropriate trial.

The students in the samples were all third formers aged between 13 - 14 years.

Dividing the sample populations into Experimental and Control Groups.

The students in each school class were divided into two groups according to their score on Pretest 7. The two groups are formed by putting into group 1 the first, fourth, fifth, eighth, ninth etc. rank order. Whilst into group 2 the second, third, sixth, seventh etc.

THE EXPERIMENTAL AND CONTROL TREATMENTS

There are two main ways of using this CAL system as an aid to classroom management; one is in its completely automatic mode, the other is by fixing the students route through the learning material at the beginning of the course.

The completely automatic mode is the more sophisticated of the two methods, but it demands firstly a clear understanding of all the difficulties the students are likely to encounter in the course, and secondly, how to remedy these difficulties as they arise. The automatic mode should be able to cater more closely for a students needs, as it will allocate CALTS on the basis of up to date information about the students performance.

Developmental costs of an automatic system are likely to be much higher than those for a non-automatic system but in theory at least it would seem likely that such a system would be more effective in some curriculum areas than a non-automatic system. The experimental and control treatments in this experiment reflect the two ways of using the CAL system. The experimental group is taught by the fully automatic

system. The control group is taught by an automated version of the way in which the teaching material was developed before the computer system was operative.

A more complete description of the way in which the teaching material for the three student ability levels was developed is given in our earlier publication (1971). Basically what we did first was to develop material suitable for use for grammar school classes. This material was refined until 90% of grammar school students obtained about 80% on the post CALT tests. The material was then tested on average ability secondary modern school students and the teaching material altered or re-written until again 80% of the students obtained about 80% on the post CALT tests. This gave us two levels of material. The third level of teaching material was developed by lacing the essential parts of the level 2 material with additional practice material and by adopting different modes of presentation. particularly using the teacher for tutorials.

The teaching material was tested by asking teachers to supply us with classes composed of students at one of the three specified ability levels. This ability level was checked by the students' performance on the pre-course test. Thus a class might be composed of average ability secondary modern school students, and with them we would run the level 2 material keeping all students at that level throughout the testing. In a grammar school all students would be given level 1 material and kept at that level.

The important things to note are that this testing was done without the computer, and that all students in a class worked at their level of entry throughout the course.

In essence the control group for the experiment is equivalent to the method used in the initial testing of the teaching material without the computer. The students in the control group were allocated to one of the three ability levels on the basis of their marks on pre test 7.

Ability Level	Pre test 7 percentage mark
1	70% and over
2	69% - 35%
3	34% and below

Their work for the course was fixed at the beginning of the course but was fed into the computer each week so they got the same type of computer output sheet as their colleagues in the experimental group. In addition this method incorporated their apparatus requirements into the apparatus list for the experimental group, thus helping to hide the fact that two groups of students were working in the same classroom. Neither the student nor teacher was aware of this grouping during the course. Table 1 summarizes the features of the experimental and control treatments.

WORK RATE OF THE TWO GROUPS

In the fully automatic CAL system as experienced by the experimental group, some account is taken of the students work rate. Each is assigned to one of three work rates before the allocation of a CALT. All students in the control group are assigned an average rate of working, and therefore they all start and finish the course at the same time. The time allowed for the whole course was five weeks, this being the time required for the students in the control group to complete the course material. During this time some students in the experimental group would complete the same amount of work as those in the control group, some less and some more, depending upon their work rate.

TABLE 1.

EXPERIMENTAL GROUP	CONTROL GROUP
Students taught by printed CALTS and teacher Tutorials.	Students taught by printed CALTS and teacher tutorials.
Amount of work allocated according to individual work rate.	The amount of work allocated to each individual is based upon an average work rate for the whole class.
Student will not receive teaching material for the whole course if he works too slowly for the time available.	Student will receive teaching material for the whole course unless he is absent.
Allocation of CALTS is stopped if individual is absent and so there are no gaps in the sequence of work completed by the student.	Absent students are allocated CALTS so that gaps in sequence may occur in their work if they do not attempt to catch up.
Student may be allocated remedial CALTS where necessary.	No remedial CALTS allocated.
Students are allocated CALTS on the basis of their performance in Pretest 7 and the CALT post tests.	Students allocated CALTS on the basis of their performance in pretest 7 only.
For each lesson the student may be routed upwards to more difficult work or downwards to easier work where necessary.	Student works throughout the course at the level allocated, on entry to the course, based upon his performance in test 7.
Student may be allocated enrichment CALTS when appropriate.	Student is not allocated enrichment CALTS.
Students are each informed of their achievement on the previous weeks work.	Students are each informed of their achievement on the previous weeks work.

TRIAL 1 : AUTUMN 1972

DURATION

Teaching time is five double lessons (75 minutes) each at weekly intervals, and five homeworks (30 minutes each).

Testing time for the pre and post course tests is 65 minutes each.

Total course length including pre and post course tests is seven weeks.

The following schools took part:

School	Description	Class Size
The Royal Liberty School	Grammar (Boys)	28
Bush Elms Secondary School	Secondary (Mixed)	15 15
Dury Falls Secondary School	Secondary (Mixed)	20 15 19
Hall Mead Secondary School	Secondary (Mixed)	24
Maylands Secondary School	Secondary (Girls)	14
	Total	150

The class sizes listed above are the student numbers on the class register and record the maxium possible number of students present in each class for each lesson during the trial.

The number of students present for the pre and post tests, and therefore included in the trial population for statistical treatment, is less than that listed above and is as follows:

School	Number of students in each class used for statistical purposes.
Royal Liberty School	20
Bush Elms Secondary School	10
Dury Falls Secondary School	16 8 12
Hall Mead Secondary School	20
Maylands Secondary School	10
Total	96

The subdivision of the statistical sample according to sex is as follows:

	MALES	FEMALES
Experimental Group	17	31
Control Group	13	35
Whole Sample	30	66

RESULTS

The data used in this section is derived from the following sources:

1. Pretest 7
2. Pretest 8
3. Post test 7
4. Post test 8
5. Students Opinion Questionnaire

Pre/Post Test 7

Results for whole sample - 48 students in each group.

	E	C	S
MEAN	53.687	50.625	52.156
VARIANCE	318.715	269.734	296.569
S.D.	17.853	16.424	17.221

	E	C	S
MEAN	67.417	59.729	63.573
VARIANCE	271.284	334.739	317.786
S.D.	16.471	18.296	17.827

Pretest 7

Post test 7

Graphs 1, 2, 3 and 4 show the distribution of test 7 scores for the statistical sample

The test 7 results for each of the ability level groups are as follows:

LEVEL 1 (26 students)

	E	C
MEAN	81.538	79.00
VARIANCE	45.940	85.385
S.D.	6.778	9.240
RANGE	24.00	28.00

	E	C
MEAN	89.308	86.615
VARIANCE	15.443	72.082
S.D.	3.930	8.490
RANGE	13.00	26.000

PRETEST 7

POST TEST 7

LEVEL 2 (60 students)

	E	C
MEAN	51.067	50.667
VARIANCE	82.796	82.889
S.D.	9.099	9.104
RANGE	31.00	31.00

Pre test 7.

	E	C
MEAN	65.633	64.067
VARIANCE	165.632	210.129
S.D.	12.870	14.496
RANGE	56.00	59.00

Post test 7

LEVEL 3 (10 students)

	E	C
MEAN	27.200	27.400
VARIANCE	10.960	12.640
S.D.	3.311	3.555
RANGE	10.00	11.00

Protest 7

	E	C
MEAN	38.00	33.600
VARIANCE	323.600	11.440
S.D.	17.989	3.382
RANGE	51.00	10.00

Post Test 7

GRAPH 1

PRETEST 7

Range	Freq	
0 - 9	0	
10 - 19	0	
20 - 29	8	XXXXXXXX XXXXXXXX XXXXXXXX
30 - 39	9	XXXXXXXXX XXXXXXXXX XXXXXXXXX
40 - 49	21	XXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXX
50 - 59	18	XXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXX
60 - 69	18	XXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXX
70 - 79	9	XXXXXXXXX XXXXXXXXX XXXXXXXXX
80 - 89	9	XXXXXXXXX XXXXXXXXX XXXXXXXXX
90 - 99	4	XXXX XXXX XXXX
	96	

GRAPH 2

POST TEST 7

Range	Freq	
0 - 9	0	
10 - 19	1	X X X
20 - 29	2	XX XX XX
30 - 39	7	XXXXXXX XXXXXXX XXXXXXX
40 - 49	7	XXXXXXX XXXXXXX XXXXXXX
50 - 59	17	XXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXX
60 - 69	17	XXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXX
70 - 79	12	XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX
80 - 89	16	XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX
90 - 99	17	XXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXX
	96	

GRAPH 3

PRETEST 7

	Experimental Group		Control Group	
Range	Freq		Freq	
0 - 9	0		0	
10 - 19	0		0	
20 - 29	4	XXXX XXXX XXXX	4	XXXX XXXX XXXX
30 - 39	5	XXXXX XXXXX XXXXX	4	XXXX XXXX XXXX
40 - 49	9	XXXXXXXXX XXXXXXXXX XXXXXXXXX	12	XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX
50 - 59	10	XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX	8	XXXXXXXX XXXXXXXX XXXXXXXX
60 - 69	8	XXXXXXXX XXXXXXXX XXXXXXXX	10	XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX
70 - 79	5	XXXXX XXXXX XXXXX	4	XXXX XXXX XXXX
80 - 89	5	XXXXX XXXXX XXXXX	4	XXXX XXXX XXXX
90 - 99	2	XX XX XX	2	XX XX XX
	48		48	

GRAPH 4

POST TEST 7

	Experimental Group		Control Group	
Range	Freq		Freq	
0 - 9	0		0	
10 - 19	1	X X X	0	
20 - 29	1	X X X	1	X X X
30 - 39	2	XX XX XX	5	XXXXX XXXXX XXXXX
40 - 49	2	XX XX XX	5	XXXXX XXXXX XXXXX
50 - 59	10	XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX	7	XXXXXXX XXXXXXX XXXXXXX
60 - 69	9	XXXXXXXXX XXXXXXXXX XXXXXXXXX	8	XXXXXXXX XXXXXXXX XXXXXXXX
70 - 79	5	XXXXX XXXXX XXXXX	7	XXXXXXX XXXXXXX XXXXXXX
80 - 89	10	XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX	6	XXXXXX XXXXXX XXXXXX
90 - 99	8	XXXXXXXX XXXXXXXX XXXXXXXX	9	XXXXXXXXX XXXXXXXXX XXXXXXXXX
	48		48	

GAIN TEST 7

The gain of students competing pretest and post test 7 is calculated by subtracting their pretest scores from their post test scores. Results for the statistical sample are as follows:

	E	C
MEAN	12.167	11.083
VARIANCE	109.681	120.868
S.D.	10.473	10.994
RANGE	51.00	53.00

Number of students = 96

The mean score on pretest 7 is approximately 56%. If the statistical sample is divided into two groups, the first having scores of 56% and above, the second having scores of 55% or below, then the following results are obtained from the gain scores of the latter group on test 7.

	E	C
MEAN	14.538	12.654
VARIANCE	137.556	157.072
S.D.	11.728	12.533
RANGE	51.0	53.00

The mean gains fro each ability level group on test 7 are as follows:

LEVEL 1 (26 students)

	E	C
MEAN	7.769	7.615
VARIANCE	38.639	26.852
S.D.	6.216	5.182
RANGE	24.00	15.00

LEVEL 2 (60 students)

	E	C
MEAN	14.233	13.400
VARIANCE	106.046	163.773
S.D.	10.298	12.797
RANGE	51.00	53.00

LEVEL 3 (10 students)

	E	C
MEAN	11. 200	6.200
VARIANCE	239.360	20.560
S.D.	15.471	4.534
RANGE	44.00	14.00

Pre/Post test 8

Results for the whole sample - 48 students in each group

	E	C
MEAN	24. 667	21.708
VARIANCE	158.556	80.915
S.D.	12.592	8.995
RANGE	63.00	46.00

Pretest 8

	E	C
MEAN	41.000	37.521
VARIANCE	322.500	308.458
S.D.	17.958	17.563
RANGE	67.000	70.00

Post test 8

Graphs 5, 6, 7 and 8 show the distribution of test 8 scores for the statistical sample.

The results for each ability level group are as follows:

LEVEL 1 (26 students)

	E	C
MEAN	33.615	30.154
VARIANCE	161.160	102.438
S.D.	12.695	10.121
RANGE	43.00	40.00

Pretest 8

	E	C
MEAN	61.692	56.846
VARIANCE	54.674	209.976
S.D.	7.394	14.491
RANGE	26.00	44.00

Post Test 8

LEVEL 2 (60 students)

	E	C
MEAN	23.233	19.033
VARIANCE	105.378	35.366
S.D.	10.265	5.947
RANGE	53.00	26.00

Pretest 8

	E	C
RANGE	33.600	31.300
VARIANCE	131.040	102.677
S.D.	11.447	10.133
RANGE	50.00	54.00

Post Test 8

LEVEL 3 (10 students)

	E	C
MEAN	9.400	16.00
VARIANCE	41.440	39.200
S.D.	6.437	6.261
RANGE	20.00	17.00

Pretest 8

	E	C
MEAN	23.400	20.600
VARIANCE	110.240	41.440
S.D.	10.500	6.437
RANGE	30.00	20.00

Post test 8

GRAPH 5

PRETEST 8

Range	Freq.	
0 - 9	3	XXX XXX XXX
10 - 19	28	XXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXX
20 - 29	43	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
30 - 39	10	XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX
40 - 49	8	XXXXXXXX XXXXXXXX XXXXXXXX
50 - 59	2	XX XX XX
60 - 69	2	XX XX XX
70 - 79	0	
	96	

GRAPH 6

POST TEST 8

Range	Freq.	
0 - 9	0	
10 - 19	7	XXXXXXX XXXXXXX XXXXXXX
20 - 29	26	XXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXX
30 - 39	23	XXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXX
40 - 49	13	XXXXXXXXXXXXX XXXXXXXXXXXXX XXXXXXXXXXXXX
50 - 59	9	XXXXXXXXX XXXXXXXXX XXXXXXXXX
60 - 69	13	XXXXXXXXXXXXX XXXXXXXXXXXXX XXXXXXXXXXXXX
70 - 79	5	XXXXX XXXXX XXXXX
80 - 89	0	
90 - 99	0	
	96	

GRAPH 7

PRETEST 8

	Experimental Group		Control Group	
Range	Freq.		Freq.	
0 - 9	2	XX XX XX	1	X X X
10 - 19	11	XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX	17	XXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXX
20 - 29	22	XXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXX	21	XXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXX
30 - 39	5	XXXXX XXXXX XXXXX	5	XXXXX XXXXX XXXXX
40 - 49	5	XXXXX XXXXX XXXXX	3	XXX XXX XXX
50 - 59	1	X X X	1	X X X
60 - 69	2	XX XX XX	0	
70 - 79	0		0	
	48		48	

GRAPH 8

POST TEST 8

Range	Experimental Group Freq.		Control Group Freq.	
0 - 9	0		0	
10 - 19	4	XXXX XXXX XXXX	3	XXX XXX XXX
20 - 29	11	XXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX	15	XXXXXXXXXXXXXXX XXXXXXXXXXXXXXX XXXXXXXXXXXXXXX
30 - 39	10	XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX	13	XXXXXXXXXXXXX XXXXXXXXXXXXX XXXXXXXXXXXXX
40 - 49	7	XXXXXXX XXXXXXX XXXXXXX	6	XXXXXX XXXXXX XXXXXX
50 - 59	6	XXXXXX XXXXXX XXXXXX	3	XXX XXX XXX
60 - 69	8	XXXXXXXX XXXXXXXX XXXXXXXX	5	XXXXX XXXXX XXXXX
70 - 79	2	XX XX XX	3	XXX XXX XXX
80 - 89	0		0	
90 - 99	0		0	
	48		48	

GAIN TEST 8

The gain of students completing pretest and post test 8 is calculated by subtracting their pretest scores from their post test scores. Results for the statistical sample are as follows:

	E	C
MEAN	15.125	15.313
VARIANCE	266.359	186.548
S.D.	16.321	13.658
RANGE	86.0	64.0

Gain for each ability level group is as follows:

LEVEL 1 (26 students)

	E	C
MEAN	28.077	27.231
VARIANCE	160.379	146.177
S.D.	12.664	12.090
RANGE	46.00	44.00

LEVEL 2 (60 students)

	E	C
MEAN	9.700	12.267
VARIANCE	229.74	132,396
S.D.	15.157	11.506
RANGE	79.00	64.00

LEVEL 3 (10 students)

	E	C
MEAN	14.00	2.600
VARIANCE	147.600	29.840
S.D.	12.149	5.463
RANGE	33.00	14.00

Based on the scores on pretest 7 the sample can be divided into two groups; one group contains students with a score of 56% or above, the other group contains students with a score of 55% and below. The following results are from the test 8 gain scores of the latter group.

26 students in each group

	E	C
MEAN	8.800	10.360
VARIANCE	138.480	71.910
S.D.	11.768	8.480
RANGE	50.00	37.00

STUDENT OPINION QUESTIONNAIRE

At the end of the trial, after they had completed their post tests, students were given an opinion questionnaire containing six questions. They were asked to select one from the three alternative answers given for each question. In addition students were asked to describe in their own words any opinions they had about the CAL course they had had recently completed.

The results for each of the six questions in the students questionnaire are listed below:

1. During CAL Biology I was given:

   A. just enough work to last through the lesson

   B. too much work

   C. too little work

	Exp.			Control			W.Sample		
	A	B	C	A	B	C	A	B	C
MEAN PERCENTAGE	73.3	18.3	8.3	82.4	3.5	14.0	79.9	9.3	10.6

2. During CAL Biology the work I was given was

   A. too difficult for me

   B. too easy for me

   C. about right for me

	Exp.			Control			W.Sample		
	A	B	C	A	B	C	A	B	C
MEAN PERCENTAGE	5.0	5.0	90.0	1.7	10.5	87.7	3.3	6.1	90.0

3. During CAL Biology most of the workI was given was

   A. very interesting

   B. interesting

   C. not very interesting

	Exp.			Control			W. Sample		
	A	B	C	A	B	C	A	B	C
MEAN PERCENTAGE	16.6	58.3	25.0	8.7	73.6	17.5	12.9	68.3	18.6

4. During CAL Biology I was given

A. too much homework

B. just enough homework

C. too little homework

	Exp.			Control			W. Sample		
	A	B	C	A	B	C	A	B	C
MEAN PERCENTAGE	23.3	53.3	23.3	7.0	66.6	26.3	15.5	62.5	21.9

5. CAL Biology lessons are:

A. as interesting as ordinary lessons

B. more interesting than ordinary lessons

C. less interesting than ordinary lessons

	Exp.			Control			W. Sample		
	A	B	C	A	B	C	A	B	C
MEAN PERCENTAGE	28.3	46.6	25.0	24.5	45.6	29.8	28.1	46.5	25.2

6. During CAL Biology lessons I think I learn

A. as much as in ordinary science lessons

B. less than in ordinary science lessons

C. more than in ordinary science lessons

	Exp.			Control			W.Sample		
	A	B	C	A	B	C	A	B	C
MEAN PERCENTAGE	35.0	15.0	50.0	35.1	24.6	40.3	35.0	19.6	45.0

TRIAL 2: SPRING 1973

DURATION

Teaching time is five double lessons (75 minutes each) at weekly intervals and five homeworks (30 minutes each).

Testing time for the pre and post course tests is 65 minutes each.

Total course length including the pre and post course tests is 7 weeks.

The following Schools took part:

School	Description	Class size
Abbs Cross Technical School	Grammar (Mixed)	33
Hall Mead Secondary School	Secondary (Mixed)	24
Hylands Secondary School	Secondary (Boys)	14
Maylands Secondary School	Secondary (Girls)	15
Rainham Secondary School	Secondary (Mixed)	33
Sacred Heart of Mary	Secondary (Girls)	32
		25
		33
	Total	209

The sizes in the eight classes listed above are the student numbers on the class register and record the maximum possible number of students present in each class for each lesson during the trial.

The number of students present for the pre and post tests, and therefore included in the trial population for statistical treatment, is less than that listed above and is as follows:

School	Number of students in each class used for statistical purposes.
Abbs Cross Technical	30
Hall Mead Secondary	18
Hylands Secondary	8
Maylands Secondary	14
Rainham Secondary	22
Sacred Heart of Mary	24
	20
	18
Total	154

Subdivision according to sex

	Males	Females
Experimental Group	23	54
Control Group	25	52
Whole Sample	48	106

LEVEL 2 (104 students)

	E	C
MEAN	54.176	54.137
VARIANCE	79.714	86.707
S.D.	8.328	9.312

PRETEST 7

	E	C
MEAN	67.588	68.039
VARIANCE	180.830	208.626
S.D.	13.447	56.00

POST TEST 7

LEVEL 3 (16 students)

	E	C
MEAN	27.125	28.500
VARIANCE	54.859	103.500
S.D.	7.407	10.173

PRETEST 7

	E	C
MEAN	50.500	44.125
VARIANCE	59.500	186.609
S.D.	7.714	13.661

POST TEST 7

RESULTS

The data used in this section is derived from the following sources:

1. Pretest 7
2. Pretest 9
3. Post test 7
4. Post test 9
5. Students Opinion Questionnaire
6. Teachers Opinion Interviews

Pre/Post Test 7

Results for statistical sample - 77 students in each group

	E	C	S
MEAN	56.078	56.156	56.117
VARIANCE	253.059	245.534	249.298
S.D.	15.908	15.67	15.798

Pretest 7

	E	C	S
MEAN	69.831	68.753	69.292
VARIANCE	242.059	309.276	276.025
S.D.	15.563	17.586	16.614

Post test 7

Graphs 9, 10, 11 and 12 show the distribution of test 7 scores for the statistical sample.

The results for each ability level group are as follows:

LEVEL 1 (34 students)

	E	C
MEAN	77.118	75.882
VARIENCE	40.104	24.927
S.D.	6.333	4.993

Pretest 7

	E	C
MEAN	85.871	85.824
VARIANCE	57.427	81.438
S.D.	7.578	9.024

Post test 7

GRAPH 9.

PRE TEST 7 SAMPLE N = 154

Range	Freq.	
0 - 9	2	XX XX XX
10 - 19	2	XX XX XX
20 - 29	4	XXXX XXXX XXXX
30 - 39	14	XXXXXXXXXXXXXX XXXXXXXXXXXXXX XXXXXXXXXXXXXX
40 - 49	29	XXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXX
50 - 59	33	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
60 - 69	38	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
70 - 79	26	XXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXX
80 - 89	3	XXX XXX XXX
90 - 99	3	XXX XXX XXX
	154	

GRAPH 10.

POST TEST 7 N = 154

Range	Freq.	
0 -9	0	
10 - 19	0	
20 - 29	1	X X X
30 - 39	5	XXXXX XXXXX XXXXX
40 - 49	17	XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX
50 - 59	18	XXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXX
60 - 69	28	XXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXX
70 - 79	38	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
80 - 89	31	XXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXX
90 - 99	16	XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX
	154	

GRAPH 11.

PRE TEST 7 SAMPLE N = 154

Range	Experimental Group Freq.		Control Group Freq.	
0 - 9	0		1	X X X
10 - 19	2	XX XX XX	1	X X X
20 - 29	3	XXX XXX XXX	1	X X X
30 - 39	5	XXXXX XXXXX XXXXX	9	XXXXXXXXX XXXXXXXXX XXXXXXXXX
40 - 49	15	XXXXXXXXXXXXXXX XXXXXXXXXXXXXXX XXXXXXXXXXXXXXX	14	XXXXXXXXXXXXXX XXXXXXXXXXXXXX XXXXXXXXXXXXXX
50 - 59	16	XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX	17	XXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXX
60 - 69	21	XXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXX	17	XXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXX
70 - 79	11	XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX	15	XXXXXXXXXXXXXX XXXXXXXXXXXXXX XXXXXXXXXXXXXX
80 - 89	2	XX XX XX	1	X X X
90 - 99	2	XX XX XX	1	X X X
	77		77	

GRAPH 12.

POST TEST 7 N = 154

	Experimental Group		Control Group	
Range	Freq.		Freq.	
0 - 9	0		0	
10 - 19	0		0	
20 - 29	0		1	X
30 - 39	1	X	4	XXXX
40 - 49	9	XXXXXXXXX	8	XXXXXXXX
50 - 59	11	XXXXXXXXXXX	7	XXXXXXX
60 - 69	12	XXXXXXXXXXXX	16	XXXXXXXXXXXXXXXX
70 - 79	23	XXXXXXXXXXXXXXXXXXXXXXX	15	XXXXXXXXXXXXXXX
80 - 89	14	XXXXXXXXXXXXXX	17	XXXXXXXXXXXXXXXXX
90 - 99	7	XXXXXXX	9	XXXXXXXXX
	77		77	

GAIN:TEST 7

The gain of students completing Pretest and post test 7 is calculated by subtracting their pretest scores from their post test scores. Results for the statistical sample are as follows:

	E	C
MEAN	13.896	13.143
VARIANCE	119.963	92.304
S D.	10.953	9.608
RANGE	61.0	46.00

The mean score on pretest 7 is approximately 56% If the statistical sample is divided into two groups, the first having scores of 56% and above, the second having scores of 55% or below, then the following results are obtained from the gain scores of the latter group on test 7.

	E	C
MEAN	16.314	12.514
VARIANCE	170.673	124.02[illegible]
S.D.	13.064	11.136
RANGE	58.00	46.00

35 students in each group

The statistical sample can be split on the basis of student scores on pretest 7 into three ability level groups. The gains for each ability level group are given below.

LEVEL 1 (Number of students = 34)

	E	C
MEAN	8.471	10.059
VARIANCE	47.308	44.526
S.D.	6.878	6.673
RANGE	25.00	25.00

LEVEL 2 (number of students = 104)

	E	C
MEAN	13.961	14.078
VARIANCE	110.665	105.602
S.D.	10.520	10.276
RANGE	49.00	44.00

LEVEL 3 (number of students = 16)

	E	C
MEAN	23.50	15.25
VARIANCE	175.50	71.937
S.D.	13.248	8.482
RANGE	48.00	29.00

Results for the statistical sample - 77 students in each group.

Pre/Post test 9

	E	C	S
MEAN	15.909	14.169	15.039
VARIANCE	75.485	58.53	67.765
S.D.	8.688	7.65	8.232

Pretest 9

	E	C	S
MEAN	33.481	33.675	33.578
VARIANCE	225.185	312.271	268.738
S.D.	15.006	17.671	16.393

Post test 9

Graphs 13, 14, 15 and 16 show the distribution of test 9 scores for the statistical sample.

The results for each ability level group are as follows:

LEVEL 1 (34 students)

	E	C
MEAN	22.529	21.353
VARIANCE	134.837	66.228
S.D.	11.612	8.138

Pretest 9.

	E	C
MEAN	50.412	51.471
VARIANCE	229.183	319.072
S.D.	15.139	17.863

Post test 9

LEVEL 2 (104 students)

	E	C
MEAN	14.588	13.020
VARIANCE	39.656	34.764
S.D.	6.297	5.895

Pretest 9

	E	C
MEAN	29.980	30.882
VARIANCE	137.902	183.398
S.D.	11.743	13.542

Post test 9

LEVEL 3 (16 students)

	E	C
MEAN	10.000	6.00
VARIANCE	47.[illegible]	15.75
S.D.	6.892	3.969

Pretest 9

	E	C
MEAN	21.625	16.750
VARIANCE	22.234	73.187
S.D.	4.715	8.555

Post test 9

GAIN : TEST 9

The gain of students completing pretest and post test 9 is calculated by subtracting their pretest scores from their post test scores. Results for the statistical sample are as follows:

	E	C
MEAN	17.701	19.338
VARIANCE	151.197	190.743
S.D.	12.296	13.811
RANGE	67.00	67.00

The gains for each ability level group are given below:

LEVEL 1 (Number of students = 34)

	E	C
MEAN	27.382	30.118
VARIANCE	162.574	215.281
S.D.	12.750	14.672
RANGE	47.00	49.00

LEVEL 2 (Number of students = 104)

	E	C
MEAN	15.382	17.706
VARIANCE	117.807	137.462
S.D.	10.854	11.724
RANGE	47.00	50.00

LEVEL 3 (Number of students = 16)

	E	C
MEAN	11.625	10.375
VARIANCE	61.984	57.484
S.D.	7.873	7.582
RANGE	25.00	21.00

Based on the scores on pretest 7 the sample can be divided into two groups; one group contains students with a score of 56% or above, the other group contains students with a score of 55% and below. The following results are from the test 9 gain scores of the latter group.

35 students in each group

	E	C
MEAN	12.143	12.343
VARIANCE	98.808	78.968
S.D.	9.940	8.886
RANGE	44.00	41.00

GRAPH 13.

PRE TEST 9 Sample = 154

Range	Freq.	
0 - 9	50	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
10 - 19	67	XXXXXXXXXXXXXXXXXXXX

GRAPH 14

POST TEST 9 Sample = 154

Range	Freq.	
0 - 9	9	XXXXXXXXX XXXXXXXXX XXXXXXXXX
10 - 19	20	XXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXX
20 - 29	50	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
30 - 39	24	XXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXX
40 - 49	24	XXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXX
50 - 59	16	XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX
60 - 69	6	XXXXXX XXXXXX XXXXXX
70 - 79	3	XXX XXX XXX
80 - 89	2	XX XX XX
90 - 99	0	
	154	

GRAPH 15.

PRE TEST 9 Sample = 154

Range	Experimental Group Freq.		Control Group Freq.	
0 - 9	12	XXXXXXXXXXXX	28	XXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXX
10 - 19	35	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	32	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
20 - 29	19	XXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXX	15	XXXXXXXXXXXXXXX XXXXXXXXXXXXXXX XXXXXXXXXXXXXXX
30 - 39	0		2	XX XX XX
40 - 49	0		0	
50 - 59	0		0	
60 - 69	1	X X X	0	
70 - 79	0		0	
80 - 89	0		0	
90 - 99	0		0	
	77		77	

GRAPH 16.

POST TEST 9 Sample = 154

Range	Experimental Group Freq.		Control Group Freq.	
0 - 9	3	XXX XXX XXX	6	XXXXXX XXXXXX XXXXXX
10 - 19	11	XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX	9	XXXXXXXXX XXXXXXXXX XXXXXXXXX
20 - 29	24	XXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXX	26	XXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXX
30 - 39	13	XXXXXXXXXXXX XXXXXXXXXXXX XXXXXXXXXXXX	11	XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX
40 - 49	14	XXXXXXXXXXXXX XXXXXXXXXXXXX XXXXXXXXXXXXX	10	XXXXXXXXX XXXXXXXXX XXXXXXXXX
50 - 59	8	XXXXXXXX XXXXXXXX XXXXXXXX	8	XXXXXXXX XXXXXXXX XXXXXXXX
60 - 69	2	XX XX XX	4	XXXX XXXX XXXX
70 - 79	1	X X X	2	XX XX XX
80 - 89	1	X X X	1	X X X
90 - 99	0		0	
	77		77	

Student Opinion Questionnaire.

At the end of each trial, after they had completed their post tests, students were given an opinion questionnaire containing six questions. They were asked to select one from the three alternative answers given for each question. In addition students were asked to describe in their own words any opinions they had about the CAL course they had recently completed.

The results for each of the six questions in the students questionnaire are listed below:

1. During CAL Biology I was given

   A. just enough work to last through the lesson.

   B. too much work.

   C. too little work.

	Exp.			Control			W.Sample		
	A	B	C	A	B	C	A	B	C
Mean Percentage	66.2	24.6	9.1	69.3	22.7	8.0	67.7	23.6	8.5

2. During C.A.L.Biology the work I was given was

   A. too difficult for me

   B. too easy for me

   C. about right for me.

	Exp.			Control			W.Sample		
	A	B	C	A	B	C	A	B	C
Mean Percentage	10.3	11.7	77.9	9.3	5.3	85.3	9.8	8.5	81.5

3. During CAL Biology most of the work I was given was

   A. very interesting

   B. interesting

   C. not very interesting.

	Exp.			Control			W.Sample		
	A.	B	C	A	B	C	A	B	C
Mean Percentage	14.3	62.4	23.3	21.3	52.0	26.6	17.7	57.2	25.0

4. During CAL Biology I was given

A. too much homework

B. just enough homework

C. too little homework.

	Exp			Control			W.Sample.		
	A	B	C	A	B	C	A	B	C
Mean Percentage	14.3	70.1	15.6	9.3	70.6	20.0	11.8	70.4	17.7

5. CAL Biology lessons are

A. as interesting as ordinary lessons

B. more interesting than ordinary lessons

C. less interesting than ordinary lessons.

	Exp			Control			W.Sample		
	A	B	C	A	B	C	A	B	C
Mean Percentage	18.2	51.9	29.9	29.3	42.6	28.0	23.6	47.4	28.9

6. During CAL Biology lessons I think I learn

A. as much as in ordinary science lessons

B. less than in ordinary science lessons

C. more than in ordinary science lessons.

	Exp			Control			W.Sample		
	A	B	C	A	B	C	A	B	C
Mean Percentage	35.1	24.7	40.2	28.0	28.0	44.0	31.6	26.3	42.1

8 DISCUSSION OF THE RESULTS OF TRIALS 1 AND 2

It is intended that this discussion will bring out the important features of the results and record various items of information which have not been included in the results section of this report, but seem relevant to the interpretation of the results. Certain features are common to the result of Trials 1 and 2, but before these are listed it is important to know the differences between the two samples as indicated by Pre Test 7 result. This test can be used as an indicator of general ability because of the wide range in its content and its correlation with the students 11-plus examination results. (cor. coeff = 0.78). The sample for trial 2 contains more high achievement students than the sample for trial 1. This is indicated by the differences in

A. Pre test 7 means (56.117 for Trial 2 and 52.156 for Trial 1)

B. Pre test 7 modal groups (60 - 69 for Trial 2, 40 - 49 for Trial 1).

Some of the difficulties involved in the interpretation of the gains on test 7 are indicated in section 4. Test 7 gains cannot be used to compare the results of ability level 1 students because their scores on protest 7 are so high. However, test 7 gain scores can be used to compare the effects of experimental and control treatments on students in ability levels 2 and 3. The features of note on test 7 results are twofold:

1. For ability levels 1 and 2 there is little or no difference in the gains of the two treatments. Mathematically none of the differences are significant.
2. For ability level 3 students there is a marked difference in gains for the two treatments on test 7 in favour of the computer routed students. However, this difference is mathematically significant only for the trial 2 results and then only at the .0.1 level. (Mann-Whitney U test)

The question which now arises is why should routing enable the weaker students in the sample to gain more than their non-routed partners?
There are at least two possible explanations for this. One is that this type of learning system is better suited for the less able student in that he is not rushed or forced to work at the pace of the more able student in the class. However, the more likely explanation probably lies in the structure of the level 3 course material, which is designed to remedy many of the weaknesses in the students repertoire of abilities as revealed by Pre test 7. Unfortunately the sample sizes for ability level 3 are very small and consequently conclusions drawn from the results can only be tentative.

The differences between Test 8 and 9 do not allow direct comparisons to be made. However, it might be argued that a similar conclusion can be drawn as from Test 7, namely that routing seems to benefit Level 3 students most. This conclusion is not as definite as that for test 7 results and we must await the next trial of the system when test 9 will be used again before a more reliable statement can be made.

The results of the students opinion questionnaire are similar for both trials. The most important point of interest revealed by the questionnaire is that somewhere between 25% and 30% of the population preferred their ordinary science lessons to CAL lessons. This promotes a variety of questions about those for whom CAL science is unattractive including the following:

1. Do these students mainly fit into one of the other categories described in this report, e.g. mostly level 1 students?
2. Are these students poor achievers in the CAL tests?
3. Are these students satisfied with school generally?
4. Are these students similar personality types?

Questions 1 and 2 can be partly answered from the results of this trial. However, no data is available at the moment to answer questions 3 and 4. After they had completed their opinion questionnaire students were asked to write in their own words their opinions of the CAL course they had just cpmpleted. These comments together with the student responses to questions 3, 5, and 6 on the questionnaire enabled us to divide the population into two groups, those students who are against the CAL system, and those students to whom it is an acceptable method of learning. Using these two categories it is possible to classify the students in each of the trials, the following tables summarise some of the classifications.

TRIAL 1 Students for and against CAL subdivided on Ability level and treatment

	Treatment	For	Against	Sample Size
LEVEL 1	Exp.	53.84%	46.15%	13
	Control	53.84%	46.15%	13
LEVEL 2	Exp.	83.33%	16.66%	30
	Control	73.33%	26.66%	30
LEVEL 3	Exp.	60%	40%	5
	Control	100%	0	5

TRIAL 2 Students for and against CAL subdivided on Ability level and treatment

	Treatment	For	Against	Sample Size
LEVEL 1	Exp.	56.25%	43.75%	17
	Control	56.25%	43.75%	17
LEVEL 2	Exp.	69.2%	30.7%	52
	Control	65.3%	34.6%	52
LEVEL 3	Exp.	100.0%	0%	8
	Control	83.3%	16.6%	8

TRIAL 1 Students for and against CAL subdivided on sex

	For	Against	Sample Size
BOYS	53.57%	46.42%	28
GIRLS	78.78%	21.21%	66

TRIAL 2 Students for and against CAL subdivided on sex

	For	Against	Sample Size
BOYS	39.58%	60.41%	48
GIRLS	79.78%	20.21%	99

Although we cannot claim that the samples used in the trials so far are wholly representative of the normal school population, the above tables do lead us to believe that

i. girls prefer the CAL system to a greater extent than boys.

ii. routing only has an effect on students opinions of the system below level 1.

Data collected during trial 1 enabled us to shorten the time allocations for each CALT stored inside the computer. In effect this meant that most students would receive slightly more work from the computer for each lesson. The effect would be most marked in the control group because the computer would always completely fill a student's work period in the automatic routing mode. The results of question 1 in the students opinion questionnaire reflects these changes, the proportion of students deciding that they had been worked too hard increasing by about 14%, the increase coming mainly from the control group side.

OPINIONS OF THE TEACHERS USING THE CAL SYSTEM

Many Computer Aided Learning Systems have been designed to be "teacher proof" in order to minimise the detrimental effects of unsympathetic teacher interference with the system. The learning material incorporated into the CAL system described in this document is designed around the class teacher, incorporating him into the system in an attempt to maximise the effect he will have on students who are working individually in the classroom. Clearly then, it is very important that the teachers using the system regard it as an asset and give as much encouragement as possible to the students, many of whom have not worked alone since leaving their primary school.

In the London Borough of Havering twelve Secondary School science teachers have used the CAL system in its completed form during the two trials.

Eleven of these twelve teachers have made available their views on the CAL system; nine of them considering the system as a worthwhile contribution to their teaching effort, two professing that the system provided no advantage over their normal teaching methods. Although none of the teachers were entirely uncritical of the system the nine pro CAL users considered the following to be the main advantages which the system provides compared with normal classroom procedures:-

1. Students gain a sound understanding of the difficulties involved in doing scientific experiments.
2. Students show a real improvement in translating written instructions into practice.
3. Students technique in handling and constructing apparatus improve considerably
4. The system promotes a healthy self reliance in most of the students which seldom appears in normal classroom situations.

Against these advantages the teachers consider the following to be the main disadvantages of using the system.

1. A considerable slice of time (five weeks) is devoted to a relatively small part of the syllabus. If the same methods were applied to the rest of the syllabus then there would not be enough time in the school year to complete the course material.
2. Students recall of basic subject matter seems to be poor.
3. Some students get bored with the repetitious nature of the work they have to do.

It is impossible to refute any of these criticisms, except perhaps the first. Certainly we have found that the time spent on the course material is necessary if students are to achieve the levels set for them. Further information concerning this problem may come to light when we attempt to run experiments comparing CAL with normal classroom procedures.

In Trial 1 the largest class contained 28 students. This is in a Grammar school and the students are normally well motivated and hardworking. Using the CAL system the teacher felt considerably overworked during the lesson trying to fulfil the constant demands of the students. This state of affairs was particularly acute at the beginning of the course but life became less hectic in ensuing weeks as both teacher and student adjusted to the demands of the situation.
In Trial 2 another Grammar School class contained 33 students and a similar pattern of events occurred with the teacher feeling quite worn out at the end of the lesson. In fact, most teachers consider that, compared with their normal lessons, they had to work much harder during CAL lessons but admitted that their lesson preparation time and marking time was less. As might be expected this was particularly noticeable for large classes of between 28 and 33 students.

One undesirable feature of the CAL lessons at the beginning of the course is the "examination atmosphere" which prevails. This tends to fade out as the course proceeds and the students and teacher become more relaxed, but it leads to students rushing through their work in order to complete it all with the result that the standard of work is lower than it might be. This occurs despite the fact that teachers are constantly reminding their charges that they should work at a pace which allows them to do the work correctly rather than just arrive at the end.

Note on significance tests used in this report.

Statistical tests applied to the data in this report include the following:

1. t test

This test was applied where the data appeared to fulfil the necessary conditions as listed below after Siegal (1956):

i. the observations must be independent.

ii. the observations must be drawn from normally distributed populations

iii. The populations must have the same variance

iv. the variables involved must have been measured in at least an interval scale so that it is possible to use the operations of arithmetic on the scores.

v. the means of these populations must be linear combinations of effects due to columns and/or rows (i.e. the effects must be additive)

2. F test

This was applied to the variances of populations to determine whether condition iii in 1 above was fulfilled. As described by Garrett (1966 page 303) to make an F test the larger variance is divided by the smaller variance and the resulting F is evaluated in terms of the appropriate degrees of freedom.

3. The Mann-Whitney U test

Whenever the data did not appear to fulfil all the requirements of the parametric t test then the Mann-Whitney U test was used as the alternative. The test was applied as described by Seigel (1956)

STATISTICAL PROGRAMS

In addition to the programs below, we have written some programs which access files and display a sub-set of their contents for answers.

Kuder-Richardson reliability test

The program picks up pretest or post test marks of students indicated by input data, and performs a Kuder-Richardson reliability test on the questions.

This method splits the pre/post test into all possible "halves", finding each reliability correlation coefficient by comparing these "halves", and then calculates the mean coefficient.

The formula used is:-

$$rel = \frac{n}{n-1} * \frac{s^2 - \sum_{i=1}^{n} p_i q_i}{s^2}$$

where
- n is the number of questions in the pre/post test.
- s^2 is the variance of the total test scores of required students.
- p_i is the proportion of students who got the correct answer for the ith question in the test.
- q_i is $1 - p_i$.

The program can be run for any of the pre/post tests, and for any specified students.

Analysis of Variance

This program will perform a one, two or three factor analysis of variance on suitable input data, as required. In doing this, the part of the variance due to each of one, two or three possible causes of variation is isolated.

If a one-factor analysis is requested, the n groups of data are input, the groups not necessarily equal in size ($n_i, i=1,n$)

Then

$$\text{total SS} = \sum_{i=1}^{n} \sum_{j=1}^{n_i} x_{ij} - CF$$

$$\text{groups SS} = \sum_{j=1}^{n} \frac{T_j^2}{n_j} - CF$$

$$\text{residual SS} = \text{SS} - \text{groups SS}$$

For a two-factor analysis, an mxn matrix is input, and the part of the variance caused by variation between rows and between columns is found.

$$\text{total SS} = \sum_{i=1}^{m} \sum_{j=1}^{n} x_{ij}^2 - CF$$

$$\text{rows SS} = \frac{\sum_{i=1}^{m} T_i^2}{\text{no. of columns}} - CF$$

$$\text{columns SS} = \frac{\sum_{j=1}^{n} T_j^2}{\text{no. of rows}} - CF$$

$$\text{residual SS} = \text{total SS} - (\text{rows} + \text{columns SS})$$

If a three-factor analysis is required, then an mxnxp matrix is input. The data is then combined into three different matrices (mxn, mxp, nxp), each combination eliminating a different cause of variation, so that three two-factor analyses can be made. In effect, the following calculations are performed:-

$$\text{total SS} = \sum_{i=1}^{m} \sum_{j=1}^{n} \sum_{k=1}^{p} x_{ijk}^2 - CF$$

mxn matrix

$$\text{rows SS} = \frac{\sum_{i=1}^{m} T_i^2}{n \times p} - CF$$

$$\text{columns SS} = \frac{\sum_{j=1}^{n} T_j^2}{m \times p} - CF$$

d) Correlation coefficient

To find the coefficient of correlation between the two samples (i.e. the two input vectors), we use the product-moment formula

$$\rho = \frac{n\sum_{i=1}^{n} x_i y_i - \sum_{i=1}^{n} x_i \sum_{i=1}^{n} y_i}{\sqrt{\left\{n\sum_{i=1}^{n} x_i^2 - \left(\sum_{i=1}^{n} x_i\right)^2\right\}\left\{n\sum_{i=1}^{n} y_i^2 - \left(\sum_{i=1}^{n} y_i\right)^2\right\}}}$$

e) F-test

The F-test is used to determine whether there is any significant difference between the two estimates of variance as calculated earlier. We calculate the value of F as:

$$\frac{s_1^2}{s_2^2} \quad \text{where} \quad s_1^2 > s_2^2$$

This is compared with the value of F tabulated at degrees of freedom $\nu_1 = n_1 - 1$, $\nu_2 = n_2 - 1$, where n_1 and n_2 are the number of elements used to calculate s_1 and s_2. Then if $F_{calc} \geq F_{tab}$, there is a significant difference between the variances.

f) T-test

A value of t for two input arrays is calculated using the formula

$$t = \frac{\bar{x} - \bar{y}}{\sqrt{\sigma^2\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}} \qquad \text{d.f } \nu = n_1 + n_2 - 2$$

where $\bar{x}$, $\bar{y}$ are the means of the two arrays
n_1, n_2 are the nos. of elements in the two arrays

$$\sigma^2 = \frac{\sum(x-\bar{x})^2 + \sum(y-\bar{y})^2}{n_1 + n_2 - 1}$$

(note: to combine the variances of the two samples in this way, it must first be established that there is no significant difference between them).

This calculated value must be compared with the tabulated value of t at ν degrees of freedom. Then if $t_{calc} \geq t_{tab}$, the result is significant, that is, there is a difference between the means.

interaction row x col = $\frac{1}{p}\sum\theta_{ij}^2$ - CF - rows SS - cols SS

Similarly for the other two 2-D matrices,

Then:

residual = total SS - rows SS - cols SS - blocks SS
- interaction row x col - interaction row x block
- interaction col x block.

Note: $CF = \frac{(\text{sum of elements})^2}{\text{number of elements}}$

In each case, the sum of squares must be divided by the corresponding degrees of freedom (one less than the no. of elements contained in the sum) and then each of these Mean Squares can be compared with the residual using F-tests.

General Statistics

This program picks up two vectors of equal length (n) from disk, outputs a copy of these vectors θ_i, i=1(1)n and performs the following statistical tests on them:

a) Mean

the mean of each vector is calculated as:

$$\frac{\sum_{i=1}^{n}\theta_i}{n}$$

b) Variance

the variance is found using the formula

$$s^2 = \frac{\sum_{i=1}^{n}\theta_i^2}{n} - \left\{\frac{\sum\theta_i}{n}\right\}^2$$

c) Standard deviation

The standard deviation from the mean of the data is the square root of the variance.

OPERATION OF C.A.L. SYSTEM

This section is concerned with the processes (expressed in operational terms) that the data goes through between arriving at the Computer Centre and leaving the Computer Centre in the form of new packs of student lessons for the next session of the course.

The data goes through seven processes, these are:-

a) Initial checking - here the data is checked to ensure that the student has completed correctly his class code and student code and where there are two answer sheets for one learning task, these are put together in the right order.

b) Punching - here the student's answers are converted into punched paper tape (we do not verify except by visual means).

c) Checking and Correcting Tapes - 2 people are involved in this process. Tapes are checked for punching errors and also for mis-interpretation of the student's writing (which can, of course, in some cases be very bad). It is more economical to use two people for this task than one person taking more than twice as long.

d) Run Time - This is the total time spent on the computer for any group of students. This includes all operator intervention and setting up and changing discs etc.

e) Dumping - This time is spent making security copies of discs in case there is a hardware, software or operator fault which causes us to lose data.

f) Splitting up Computer Output - Computer output is on three part stationery; one copy to the school, one copy for the archives and one copy for the research team. These items have to be decollated and burst - no equipment is available for this.

g) Making up packs - At the moment the student's individual output is taken and a member of the Computer Centre's staff makes up for the student his lesson pack by pulling from files individual work tasks in the order in which they are mentioned in the student output.

In the first set of trials the checking and correcting of the punching was done by one person, now in view of the experience gained two people undertake this task and it is quicker and cheaper. Secondly, we originally used three part staticnery interleaved with one time carbon. This carbon had to be removed and destroyed. It was a dirty task which doubled the time for splitting up output. We are now using a self copying paper which more than justifies its extra expense in terms of labour.

The total population used in these statistics is 205 students; 33 from selective schools the remainder from non-selective schools. Class sizes were as follows:-

31, 31, 24, 16, 32, 33, 14 and 24 students

The table below gives the time taken for each of the seven tasks outlined at the beginning of this section along with the cost of performing this task for 100 students.

Operation	Time mins	Cost per hour	Cost per 100 students
Initial Checking	33.57	£1-00	£0-56
Punching	193.02	£1-00	£3-22
Checking and Correcting Tapes	98.12	£2-00	£3-27
Run Time	79.79	£8-50	£11-30
Dumping	11.80	£8-50	£1-67
Splitting up	12.55	£1-00	£0-21
Making up	81.77	£1-00	£1-36
			£21-59

The above table is based upon preparing an hour's work for each of 100 students.

The projected cost at the end of the first trial was over £25-00; some operational changes we made has reduced this to the figure given in the table above. This system is attempting to do things which are not done in conventional teaching and it is being used in an alien environment, thus these costs are over and above those of conventional teaching. This cost appears very high for "run of the mill" teaching, although justifiable where there are special educational or social benefits or where the cost of conventional teaching is higher than it is at the secondary level (e.g. Further education, Industrial training etc.)

For non-research use of the system, schools will use pre-printed versions of the texts and will hold a library of these which the students can select for themselves as required. This will cut out the making up costs. The splitting up cost is due to the fact that for research purposes three copies of the computer output, of which only one goes to the school, are made. For production work this will be reduced to one and there will be no splitting up done centrally.

The dumping costs for making security copies would be lower on a multi-disc drive system because the majority of time is spent waiting for discs to come up to speed and slow down again.

The run-time costs will be reduced by reducing operator intervention in the programs.

Methods of reducing the other three costs are being investigated.